DWARF MISTLETOE–PANDORA MOTH INTERACTION AND ITS CONTRIBUTION TO PONDEROSA PINE MORTALITY IN ARIZONA

Michael R. Wagner[1] and Robert L. Mathiasen[1]

ABSTRACT.— The interaction between Southwestern dwarf mistletoe, *Arceuthobium vaginatum* subspecies *cryptopodum*, infestation and defoliation by the pandora moth, *Coloradia pandora pandora*, on the Kaibab Plateau in Arizona was evaluated. Heavy defoliation of ponderosa pine, *Pinus ponderosa*, in 1979 and 1981 resulted in mortality of individual trees in areas of heavy dwarf mistletoe infestation. Postmortem evaluation of ponderosa pines indicated that dead trees had a significantly higher dwarf mistletoe rating than did nearby paired live trees. Of 25 tree pairs evaluated, only two live trees had higher dwarf mistletoe ratings than the paired dead tree. Mean dwarf mistletoe ratings were: live trees 2.9, dead trees 4.6 (6 class dwarf mistletoe rating system). Implications for management of the pandora moth are discussed.

An outbreak of the pandora moth, *Coloradia pandora pandora* Blake (Lepidoptera: Saturniidae), began in 1979 on the Kaibab Plateau in northern Arizona. Defoliation of ponderosa pine, *Pinus ponderosa* Dougl. ex Laws., occurred over 5,000 acres in 1979 and 19,000 acres in 1981 (Bennett and Ragenovich 1982). Pandora moth defoliation resulted in radial growth loss between 17% (Miller 1983) and 25% (Bennett and Andrews 1983). Tree mortality was not significantly greater in defoliated plots than nondefoliated control plots (Bennett and Andrews 1983). Though there was no significant effect of defoliation on mortality on a stand basis, there were clearly small pockets of mortality (Wagner pers. obs.). Field observations by the authors indicated that many of the trees that died were infected with Southwestern dwarf mistletoe, *Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawksw. & Wiens. Bennett and Andrews (1983) found that radial growth loss in trees with mistletoe and pandora moth was greater than for those with only pandora moth in this area.

Many insects and diseases do not cause direct serious impact on their host but rather function to predispose trees to other damaging agents. Numerous authors have reported that pandora moth defoliation increased the incidence of bark beetle mortality (Carolin and Knopf 1968, Keen 1952, Massey 1940, Patterson 1929, Wygant 1941). Dwarf mistletoes, which are serious damaging agents in western forests (Hawksworth 1961, Hawksworth and Wiens 1972), are a common agent predisposing trees to other agents. The numerous interactions between dwarf mistletoes and forest insects have been reviewed by Stevens and Hawksworth (1984). We report in this paper that ponderosa pine mortality, following the pandora moth outbreak in northern Arizona, occurred primarily on trees heavily infected with dwarf mistletoe.

MATERIALS AND METHODS

The study site was approximately two miles north of Jacob Lake, Arizona, in an area heavily defoliated in 1979 and 1981 by the pandora moth. The sample area was approximately 100 acres in size and constituted the largest pocket of mortality that had occurred following defoliation (Wagner pers. obs.). The study site was outside the area sprayed with Acephate® in 1981 (based on maps in Bennett and Ragenovich 1982).

A systematic sample with a random start was used to survey the area of mortality. Sample plots were two chains apart and one chain in radius. The nearest dead tree to the plot center was selected, and the nearest live tree of similar diameter (maximum acceptable difference four inches dbh) identified (Fig. 1). The diameter breast height (dbh) and 6-class dwarf mistletoe rating (DMR) (Hawksworth

[1]School of Forestry, Box 4098, Northern Arizona University, Flagstaff, Arizona 86011.

Fig. 1. Typical paired sample of a living and dead ponderosa pine. Note the heavier dwarf mistletoe infection on the dead tree.

TABLE 1. Mean diameters and dwarf mistletoe ratings of paired live and dead ponderosa pines.

	Live trees		Dead trees	
	dbh	DMR	dbh	DMR
Mean ($\bar{X}$)	16.4	2.84	16.5	4.64
SD	8.1	1.75	8.1	1.35
Range	5.9–35.9	0–6	5.6–34.2	1–6

1977) were determined for each tree in the pair. If a suitable pair of trees could not be located within a plot, the plot was rejected. A total of 38 plots were examined, of which 25 met the criteria of having a suitable pair of trees.

Data were analyzed using a nonparametric sign test (Conover 1980) ($\alpha = 0.05$). The sign test indicates whether one random variable in a pair tends to be larger than the other random variable in the pair. The null hypothesis was that there was no difference in the dwarf mistletoe ratings between dead and live trees in the stand.

RESULTS

The mean diameters and mean DMR's of the paired trees are given in Table 1. There was no statistically significant difference in mean dbh between live and dead trees, as should be expected because of the pairs chosen. However, there was a highly significant difference in the mean DMR of live and dead trees. Dead trees sampled generally had signs of heavy dwarf mistletoe infection (DMR 5 or 6). Dead trees had a higher mean DMR rating than their paired live trees in all but two sampled pairs, where the live tree had a higher DMR than the dead tree. We observed that the mortality occurred over a considerable range of tree diameters. None of the dead trees we examined were free of dwarf mistletoe.

DISCUSSION

Our data indicate ponderosa pine mortality tended to occur on trees that were heavily infected with dwarf mistletoe. We can conclude that the probability of mortality as a result of pandora moth defoliation is greater in stands heavily infested with dwarf mistletoe. Our experimental design does not permit the establishment of a cause-effect relationship, but it appears reasonable that dwarf mistletoe is predisposing trees to mortality following defoliation. We do not feel there is evidence to suggest that the pandora moth prefers dwarf-mistletoe-infested trees, since defoliation is often uniform over large areas. Rather, we feel trees weakened by dwarf mistletoe infection probably are less tolerant of defoliation than are healthier trees. We did not attempt to systematically determine the cause of mortality of each sampled tree in the study area. However, the few trees we did examine did not appear to be killed by bark beetles or other secondary agents.

These findings have important implications for management of the pandora moth. Since growth loss is moderate and probably does not occur for more than one or two years, control attempts directed at reducing growth loss are not justified. Mortality is a more serious impact and would justify control measures if expected to occur over large areas. We would recommend controlling the agent predisposing trees to mortality (dwarf mistletoe) as the preferred option. Silvicultural control strategies for dwarf mistletoes are well established (Scharpf and Parmeter 1978). We would specifically recommend selectively removing trees with a DMR of 3.0 or greater in stands likely to be heavily defoliated by the pandora moth. Because the importance dwarf mistletoes play in reducing growth is well known (Hawksworth and Wiens 1972), the added effect of expected defoliation would certainly justify control efforts in managed forest stands.

In forest areas not under intensive forest management, defoliation by the pandora moth may actually have a beneficial effect. Since mortality preferentially occurs on the more heavily dwarf-mistletoe-infected trees, pandora moth defoliation may have the affect of reducing stand mistletoe infestation levels. This may increase the desirability of these areas for future use as managed stands. Certainly the mortality of some trees would provide considerable wildlife habitat for a variety of cavity-nesting birds.

ACKNOWLEDGMENT

We acknowledge E. A. Blake and J. M. DiMatteo for their assistance in data collection.

Literature Cited

Bennett, D. D., and M. A. Andrews. 1983. Biological evaluation of the pandora moth—Kaibab National Forest. USDA Forest Service. Southwestern Region, Forest Pest Management Report R-3 83-7. 15 pp.

Bennett, D. D., and I. R. Racenovich. 1982. A pilot control project to evaluate Acephate® for control of the pandora moth, *Coloradia pandora* Blake (Lepidoptera: Saturniidae), Jacob Lake, Arizona 1981. USDA Forest Service. Southwestern Region, Forest Pest Management Report R-3 82-10. 36 pp.

Carolin, V. M., and J. A. E. Knopf. 1968. The pandora moth. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. Forest Pest Leaflet 114. 7 pp.

Conover, W. J. 1980. Pages 122–142 *in* Practical nonparametric statistics, 2d ed., John Wiley & Sons Inc., New York.

Hawksworth, F. G. 1961. Dwarf mistletoe of ponderosa pine in the Southwest. USDA Forest Service Technical Bulletin 1246. 112 pp.

_____. 1977. The 6-class dwarf mistletoe rating system. USDA Forest Service. General Technical Report RM-48. 7 pp.

Hawksworth, F. G., and D. Wiens. 1972. Biology and classification of dwarf mistletoes (*Arceuthobium*). USDA Forest Service Agriculture Handbook 401. 234 pp.

Keen, F. P. 1952. Pages 83–86 *in* Insect enemies of western forests. USDA Miscellaneous Publication 273.

Massey, C. L. 1940. The pandora moth (*Coloradia pandora* Blake), a defoliator of lodgepole pine in Colorado. Unpublished thesis. Duke University, Durham, North Carolina. 33 pp.

Miller, K. K. 1983. The ecology and impact of the pandora moth, *Coloradia pandora pandora* Blake, in northern Arizona. Unpublished thesis. Northern Arizona University, Flagstaff. 62 pp.

Patterson, J. E. 1929. The pandora moth, a periodic pest of western pine forests. USDA Technical Bulletin 137. 20 pp.

Scharpf, R. F., and J. R. Parameter, eds. 1978. Proceedings of the symposium on dwarf mistletoe control through forest management. USDA Forest Service General Technical Report PSW-31. 190 pp.

Stevens, R. E., and F. G Hawksworth. 1984. Insect-dwarf mistletoe associations: an update. Pages 94–100 *in* Proceedings biology of dwarf mistletoe. USDA Forest Service General Technical Report RM:111.

Wycant, N. D. 1941. An infestation of the pandora moth, *Coloradia pandora* Blake, in lodgepole pine in Colorado. J. Econ. Ent. 34(5):697–702.